International Journal of Advanced Culture Technology Vol.8 No.1 19-25 (2020)
DOI https://doi.org/10.17703/IJACT.2020.8.1.19

IJACT 20-2-3

A study of the incubator model for growing mushrooms

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Abstract

This article describes the automated incubator designs for white mushrooms growing. Mongolia has a very long and cold winter, so the process of growing mushrooms is short. Therefore, we aim to design an automated incubator system that has created a favorable artificial environment for mushroom growing by examining the necessary conditions for mushroom growing. This system was designed to be able to hold for some time the required levels of soil moisture, air humidity, soil temperature, air temperature, and CO2 levels. This article presents the results of a system-based experiment that allows you to grow mushrooms for 30 days without human interference.

Keywords: *automatic, control system, sensors, microcontroller, algorithm*

1. Introduction

Today, Mongolia imports 100% of its edible mushrooms. Mushrooms are good for health when used immediately. In this regard, we are conducting research on the possibility of growing mushrooms in Mongolia. In our study (Pleurotus ostreatus), oyster mushrooms were selected, and we aimed to design an incubator capable of growing them. Oyster mushrooms are not only tasty but also nutritious, and have long been widely used by people in medicine, and dietary supplements. This type of mushroom has high medicinal properties and use. Oyster mushrooms are a source of digestible protein in diabetics and also contribute to both normalizing blood pressure and hypertension [1-3]. The oyster mushroom has a good ability to handle high pressures. In recent decades, it has become clear that not only the cancer-causing, antibacterial and other activities having a general tonic effect are not only the "exotic" of Asian cultivars, but also the popular Chaga, several types of medicinal yeasts, and oyster mushrooms, as our most common wild forest mushrooms [3, 4]. It also contains many biologically active substances, which are better than beef, have amino acids, increase immunity, reduce blood pressure and fever, lower cholesterol, and have antiviral, anti-inflammatory, and anti-tumor effects [5-7]. Studies show that the protein content of mushrooms is very high [8-10]. In this study, we aimed to create a fully automatic mushroom incubator model within the framework of a thorough study of mushroom growing conditions. When planting mushrooms it is necessary to pay attention to air and soil temperature, air and soil moisture, light, CO2 and PH. This article presents the results of a sustainable control model for mushroom growing conditions.

Manuscript received: November 30, 2019 / revised: December 25, 2019 / Accepted: January 2, 2020
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2. A study of the growing environment

Oyster mushrooms grow in the wild between July and November in Mongolia. The growing environment for this mushroom is shown in Table 1 for 30 days. In it, we consider ambient temperature, soil and air humidity, light, pH, and CO2.

Table 1. The environment of growing oysters

Days \Environ.	Air temp. (ºC)	Soil hum. (%)	Air hum. (%)	Light	PH	CO_2
2	24-28	60-65	60-70	Small	6-7	<10%
4	24-28	60-65	60-70	Small	6-7	<10%
6	24-28	60-65	60-70	Small	6-7	<10%
8	24-28	60-65	60-70	Small	6-7	<10%
10	24-28	24-28	60-70	Small	6-7	<10%
12	24-28	60-65	60-70	Small	6-7	<10%
14	24-28	60-65	60-70	Small	6-7	<10%
16	13-20	65-70	85-95	Middle	6-7	<10%
18	13-20	65-70	85-95	Middle	6-7	<10%
20	13-20	65-70	85-95	Middle	6-7	<10%
22	13-20	65-70	85-95	Middle	6-7	<10%
24	13-20	65-70	85-95	Middle	6-7	<10%
26	13-20	65-70	85-95	Middle	6-7	<10%
28	13-20	65-70	85-95	Middle	6-7	<10%
30	13-20	65-70	85-95	Middle	6-7	<10%

A. Temperature:

Oyster mushrooms are grown at a temperature of 5 °C ~ 35 °C. The optimal temperature is 24 °C ~ 28 °C. The temperature range is 7 °C~ 28 °C, 15 °C ~ 18 °C. Do not go above 36 °Cor below 5 °C.

B. Humidity:

Soil moisture content during the growth of oysters is 60% -66%, air humidity is 60% ~ 70%. Shell growth is slow when the soil moisture content is poor. When the soil water content is too high, the gas permeability is poor and the oysters slowly grow and bacteria or mold can grow easily. The fruit body grows quickly and vigorously when the fruiting period is 70% ~ 75% and relative humidity 85% ~ 95%. When the mushroom cap expands, when the humidity is below 80%, the hat is easy to dry and crack, but when it is longer than 95% it can rot.

C. Air and CO2:

Oxygen and carbon dioxide are important factors in the growth and development of white mushrooms. Normally, the normal oxygen content is about 21% and the carbon dioxide content is about 0.03%. Oyster mushrooms absorb oxygen and release carbon dioxide during inhalation. Too high carbon dioxide levels can affect the growth of mushrooms. If the air does not flow and there is not enough oxygen, it will hinder the growth and development of the fruit body. Carbon dioxide below 0.1% is optimal.

D. Light:

The growth of the mycelium of Pleurotus ostreatus is light-requiring, but light inhibits the growth of the hyphae. Therefore, during development, it is necessary to provide conditions of dark or low light. However, the formation or growth of the fruit body requires the development of light, especially the primary in the fruit body. In addition, the intensity of light affects the color of the fruit body and the length of the handle. On the contrary, in strong light conditions, the fruit body is thicker and darker with a thicker flesh, and if there is not enough light, the fruit body is pale, with a long stem and thin flesh, and the essence is low.

E. pH (pH):

Pleurotus ostreatus can grow between pH 3.5-9.0 and suitable pH 5.4 ~ 7.5.

3. The design and system solution of the incubator

The design of the incubator we created can be seen in Figure 1. The outer container of the incubator was used as a plastic container with a light-transmitting ability. An electric heater is installed under the tank to heat the soil. The DHT22 sensor, the air temperature, and humidity sensor, and the MQ135 sensor for measuring CO_2 in the tank are mounted on the walls of the tank. Soil temperature DS18B20 was also used for each soil moisture sensor.

Figure 1. Incubator

Irrigation is watered as raindrops from above a container, creating a humidifier with air humidity. The airflow is generated by an electric fan. To create airflow we drilled holes opposite sides to the electric fan. Airflow control is one of the most important parameters. If there is too much airflow the soil and mushroom cap started to dry and body of the fruit does not expand Fig.2. If there is not enough airflow, oxygen for mushroom not enough and the body of the mushroom getting small.

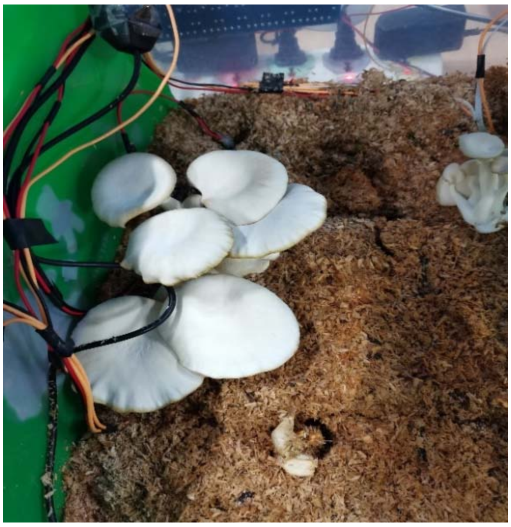

Figure 2. Mushroom cap started to dry

The schematic diagram of system control is shown in Figure 3. With the help of timer determine the daily growing conditions. Very important is to choose the right sensor, for example, some soil moisture sensor does not meet requirements. In wet soil environment, the sensor corroded and unable to work for a long time.

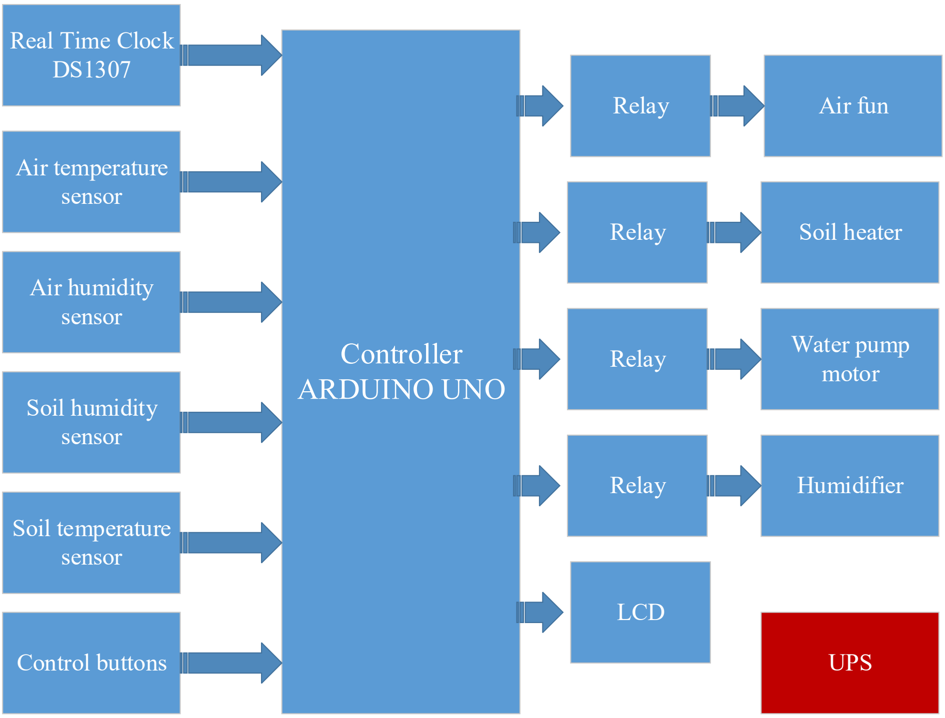

Figure 3. Scheme of the control structure

In this study, we addressed the issue of incubator control to resolve hardware and software problems. We have developed a control model to maintain the ambient air and soil temperature, air and soil moisture indicators to provide an environment where oyster mushrooms can grow. We studied and compared many control algorithms and we developed own new control algorithm. The control algorithm shown in Figure 4.

The humidity is influenced by the moisture from the soil and the humidity from the humidifier, and we keep the air humidity steady through the flow of air. To control the incubator environment, we cannot rely only on sensor data. The soil humidity sensor measures a small area of incubator and to irrigate the soil we first check sensor value or every morning we made small irrigation. In addition, we keep the soil temperature and air temperature constant. With the real time clock, we count the days and create a mushroom growing environment according to the parameters given in Table 1.
An uninterruptible power supply provides emergency power to the incubator when the input power source fails.

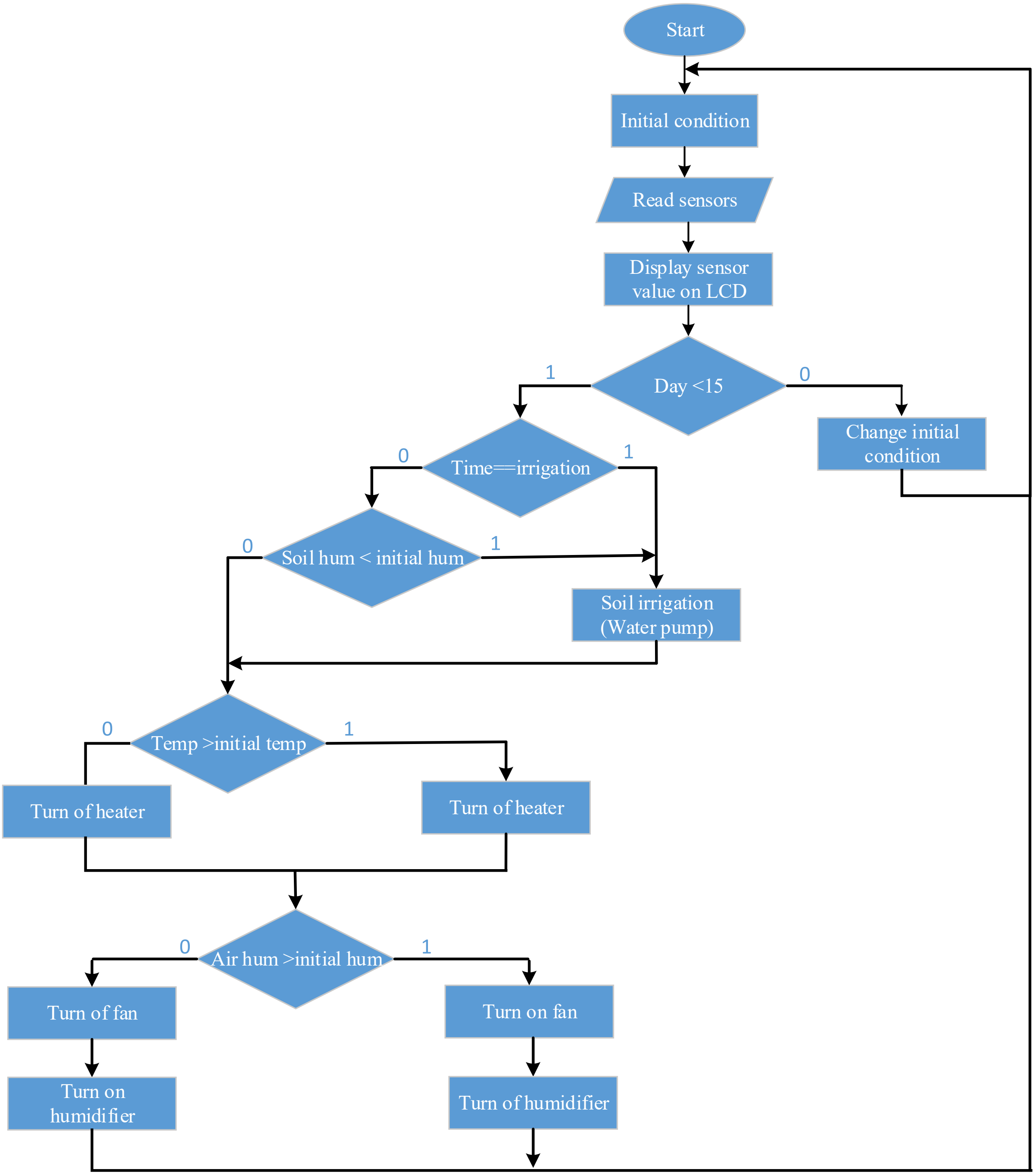

Figure 4. Algorithm for controlling air humidity

5. Test results

Some results of the system operation can be seen in Figures 5 and 6. Figure 5 shows that the soil and air temperature are stable. Figure 6 shows the results of a test that holds air humidity with the help of a fan.

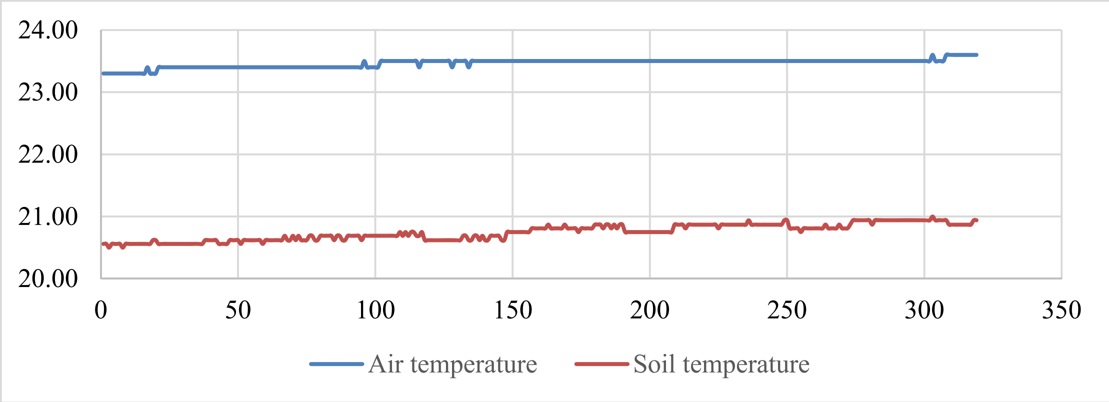

Figure 4. The result of maintaining a stable temperature

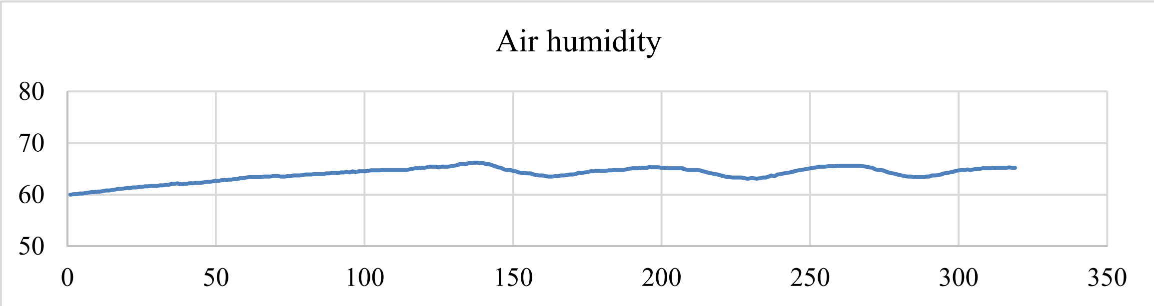

Figure 5. The result of stabilization of air humidity

The mushroom growth process is shown in Figure 6.

Figure 6. The process of growing oyster mushrooms

6. Conclusion

The first prototype of the incubator to meet the growing conditions of the mushroom was created and experiments were conducted to maintain a stable temperature and humidity of the air. In the first experiment, the soil was moldy due to the excess moisture content and the lack of air exchange. The air can be adjusted by controlling the airflow through the fan through the soil moisture. One of the main parameters was to control the airflow of the incubator.

Our incubator tested continuously in four months without human interference. In this period, we crop harvested four time mushrooms. The first crop gave 300g, the second, third and fourth yields 100g each. In this pleasant environment, insects began to breed.

Our designed incubator consumes 9.5 W of power. Further research aims to improve control methods to reduce power consumption.

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